

What is Claimed:

1 1. A method of treating water to produce a mixture of
2 monochloramine and chlorine dioxide in said water, comprising the steps of:

3 injecting a mixture of chlorine and chlorine dioxide into said water
4 together with ammonia, said ammonia being present in an amount to react with the
5 chlorine to produce monochloramine with substantially no residual chlorine in
6 said water.

1 2. A method according to claim 1 including the step of storing a
2 portion of said water containing chlorine dioxide and chloramine for use as a water
3 treatment solution.

1 3. A method of preparing a water treatment solution for use in
2 treating drinking water comprises the steps of:

3 accumulating a volume of said water to be treated;

4 injecting a mixture of chlorine and chlorine dioxide into said volume
5 of water together with ammonia, said ammonia being present in an amount to
6 produce monochloramine with substantially no residual chlorine in said water.

1 4. A method for treating water as it proceeds from a source to a
2 storage or distribution facility comprising the steps of:

3 injecting a mixture of chlorine and chlorine dioxide into said water at
4 a location between said source and said storage or distribution facility; and

5 injecting ammonia into said water at either a point upstream or
6 downstream of said location where said chlorine and chlorine dioxide are injected
7 into said water, said ammonia being injected in an amount to react substantially
8 with said chlorine, whereby said water in said storage or distribution facility
9 contains chlorine dioxide, monochloramine and a negligible amount of chlorine.

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1 5. A process according to claim 4 including the step of
2 establishing the chlorine:ammonia ratio at or below 5:1 by weight.

1 6. A process according to claim 4 including the step of injecting
2 the ammonia downstream of the chlorine/chlorine dioxide injection point, but
3 sufficiently close to the chlorine/chlorine dioxide injection point so that
4 substantially all of the chlorine is converted to monochloramine before chlorinated
5 organics can be formed at levels that are above acceptable limits.

1 7. A process according to claim 4 wherein the water is
2 contaminated raw water and the treatment process includes the step of applying the
3 ammonia/chlorine/chlorine dioxide stream to the raw water before other treatment
4 steps.

1 8. A process according to claim 4 including the steps of injecting
2 the chlorine dioxide early enough in the process so that chlorine dioxide is at an
3 acceptable level for entry into the water distribution system.

1 9. A process according to claim 4 including the step of creating
2 enough monochloramine to be carried through all treatment steps following its
3 creation to provide all or part of the necessary disinfection in a distribution system.

1 10. A process according to claim 7 including the step of applying
2 the ammonia/chlorine/chlorine dioxide stream in a raw water main near the intake
3 of the main wherein the chlorine dioxide reacts with contaminants as the raw water
4 flows through said main.

1 11. A process according to claim 4 including the step of using the
2 ammonia/chlorine/chlorine dioxide stream to either oxidize contaminants or
3 disinfect drinking water with production of chlorinated by-products kept within
4 acceptable limits.

1 12. A method for treating water wherein a stream containing
2 chlorine and chlorine dioxide is used to treat drinking water, wherein the mixed

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chlorine/chlorine dioxide stream (either as gas or in solution) is injected into the water being treated, and where the point of injection is after THM precursors are removed from the water, such that the level of chlorinated by-products created is within acceptable limits..

13. A method for treating water comprising the steps of:

a) providing a stream containing chlorine and chlorine dioxide

b) separating the mixed chlorine/chlorine dioxide stream into two streams, the first of which contains chlorine dioxide that is substantially chlorine-free, and the second stream contains chlorine with a lower level of chlorine dioxide than in the original stream;

c) injecting the stream of chlorine into said water being treated at point in the process after removal of sufficient organic material such that the level of chlorinated organics created is at or below an acceptable level; and

d) using the chlorine dioxide stream to oxidize contaminants and disinfect drinking water at a point in the process before sufficient organics have been removed to allow treatment with a stream containing substantial amounts of chlorine.

14. A process according to claim 13, including the step of injecting ammonia into said water containing chlorine entering a distribution system for treated water to convert said chlorine to monochloramine.

15. A method for treating water using a stream containing chlorine and chlorine dioxide comprising the steps of:

separating the chlorine from the chlorine dioxide to yield a stream of chlorine and a stream of chlorine dioxide;

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5 using said chlorine dioxide to pre-oxidize a stream of raw water prior
6 to further processing, such as clarification, being one of, a combination of, or all of
7 the steps of coagulation, flocculation and sedimentation, filtration, dissolved air
8 flotation, and membrane filtration;

9 subjecting said water after treatment with chlorine dioxide to further
10 processing, such as clarification being one of, a combination of, or all of the steps
11 of coagulation, flocculation and sedimentation, filtration dissolved air flotation,
12 and membrane filtration; and

13 using said chlorine to disinfect said water after said further
14 processing and prior to storage for distribution.

1 16. A method according to claim 15 including the step of adding
2 ammonia to said water as it is withdrawn from storage for distribution to create
3 residual monochloramine in said water for distribution.

1 17. A method according to claim 16 including the step of
2 establishing the initial chlorine:ammonia ratio at or below 5:1 by weight.

1 18. A method for treating and disinfecting raw or partially treated
2 water comprising the steps of:

3 introducing a mixture of chlorine, chlorine dioxide and ammonia into
4 said raw or partially treated water to provide disinfection of the water by chlorine
5 dioxide and creation of monochloramine by reaction of chlorine and ammonia;

6 passing said raw water through subsequent treatment processes,
7 such as clarification being one of, a combination of, or all of the steps of
8 coagulation, flocculation and sedimentation, filtration; dissolved air flotation, and
9 membrane filtration, whereby residual chlorine dioxide is substantially consumed
10 prior to distribution; and

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collecting a potable finished water containing sufficient residual monochloramine to provide adequate residual disinfection of said finished water.

19. A method according to claim 18 including the step of adding ammonia and chlorine to said potable water as it is introduced into a distribution system to create monochloramine in said water.

20. A method according to claim 18 including the step of withdrawing a side stream of raw or partially treated water, introducing ammonia, chlorine and chlorine dioxide into said side stream which is then recycled into a main stream of said water.

21. A method according to claim 19 including the step of establishing the initial chlorine:ammonia ratio at or below 5:1 by weight.

22. A method of treating contaminated raw water comprising the steps of:

a) introducing a mixture of chlorine dioxide and monochloramine into said raw water to cause pre-oxidation by said chlorine dioxide and introduce monochloramine into said water as it proceeds through subsequent processing steps;

b) passing said water from step "a" through further processes, such as clarification being one of, a combination of, or all of the steps of coagulation, flocculation and sedimentation, filtration, dissolved air flotation, and membrane filtration, to effect solids removal; and

c) treating said water after solids removal and prior to storage with one of chlorine dioxide, a mixture of chlorine dioxide and chlorine, or a mixture of chlorine dioxide, chlorine and ammonia for disinfection.

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1 23. A method according to claim 22 including the step of
2 introducing said ammonia at each location at a ratio of chlorine:ammonia of 5:1 or
3 less by weight.

1 24. A method according to claim 22, including the step of
2 introducing ammonia into water as it is withdrawn from storage when said
3 withdrawn water contains residual chlorine.

1 25. A method according to claim 24 including the step of
2 introducing said ammonia at a ratio of chlorine:ammonia of 5:1 or less by weight.

1 26. A method of treating water using streams of chlorine dioxide,
2 chlorine and ammonia comprising the steps of:

3 a) introducing chlorine dioxide into raw water in a raw water main;

4 b) subjecting said raw water containing chlorine dioxide to
5 subsequent processing steps such as clarification being one of, a combination of,
6 or all of the steps of coagulation, flocculation and sedimentation, filtration;
7 dissolved air flotation, and membrane filtration;

8 c) introducing additional chlorine dioxide into said water as it is
9 withdrawn from step "b" and conducted to finished water storage; and

10 d) introducing chlorine and ammonia into water entering finished
11 water storage or as it is withdrawn from storage for distribution to users to provide
12 monochloramine in said water by reaction of chlorine and ammonia.

1 27. A method according to claim 26 including the step of
2 introducing said ammonia into said water in step "d" at a ratio of chlorine:
3 ammonia of 5:1 or less by weight.

1 28. A method for treating water processed in a drinking water
2 treatment plant through various process steps, including solids removal, by

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3 introducing a mixture of chlorine dioxide and chloramine into said water after said
4 solids-removal step.

1 29. A method according to claim 28, including the step of
2 preparing said mixture of chlorine dioxide and chloramine by adding ammonia to a
3 mixture of chlorine and chlorine dioxide at a ratio of chlorine:ammonia of 5:1 or
4 less by weight.

1 30. A method according to claim 28, including the step of
2 withdrawing a side stream of water after said solids removal step, introducing
3 chlorine dioxide and monochloramine into said side stream, and injecting said side
4 stream of water containing chlorine dioxide and monochloramine into said water
5 downstream of where said side stream is withdrawn.

1 31. A method according to claim 27 including the step of
2 withdrawing a side stream of water after said solids-removal step, introducing
3 chlorine dioxide, chlorine and ammonia into said side stream, said chlorine:
4 ammonia ratio being 5:1 or less in said side stream, and introducing said side
5 stream into said water downstream of where said side stream is withdrawn.

1 32. A method for treating water comprising the steps of:

2 a) providing a stream containing gaseous chlorine and chlorine
3 dioxide

4 b) passing at least a portion of the gaseous chlorine and chlorine
5 dioxide stream through a porous bed of sodium chlorite to yield a first stream of
6 chlorine dioxide;

7 c) separating the remaining portion of the mixed chlorine/chlorine
8 dioxide gas stream into two streams, the first of which contains chlorine dioxide
9 that is substantially chlorine-free, and the second stream contains chlorine with a
10 lower level of chlorine dioxide than in the original stream;

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d) injecting the stream of chlorine into said water being treated at point in the process after removal of sufficient organic material such that the level of chlorinated organics created is at or below an acceptable level; and

e) combining the first stream of chlorine dioxide and the stream of chlorine dioxide substantially free of chlorine into a mixed chlorine dioxide stream and using the mixed chlorine dioxide stream to oxidize contaminants and disinfect the water at a point in the process before sufficient organics have been removed to allow treatment with a stream containing substantial amounts of chlorine.

33. A process according to claim 32 including the step of injecting ammonia into said water containing chlorine entering a distribution for treated water system to convert said chlorine to monochloramine.

34. A method for treating water using a stream containing gaseous chlorine and chlorine dioxide comprising the steps of:

passing at least a portion of the stream containing gaseous chlorine and chlorine dioxide through a porous bed of sodium chlorite to yield a stream of chlorine dioxide;

separating the remaining portion of the chlorine from the chlorine dioxide to yield a stream of chlorine and a stream of chlorine dioxide containing negligible amounts of chlorine;

combining said stream of chlorine dioxide and said stream of chlorine dioxide containing negligible amounts of chlorine into a mixed chlorine dioxide stream and using said mixed chlorine dioxide stream to pre-oxidize a stream of raw water prior to further processing, such as clarification being one of, a combination of, or all of the steps of coagulation, flocculation and sedimentation, filtration, dissolved air flotation, and membrane filtration; and

using said chlorine to disinfect said water after further processing, such as clarification being, one of, a combination of, or all of the steps of

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17 coagulation, flocculation and sedimentation, filtration, dissolved air flotation, and
18 membrane filtration and prior to storage for distribution.

1 35. A method according to claim 34 including the step of adding
2 ammonia to said water as it is withdrawn from storage for distribution to create
3 monochloramine in said water for distribution.

1 36. A method according to claim 35 including the step of
2 establishing the initial chlorine:ammonia ratio at or below 5:1 by weight.

1 37. A method for treating water comprising the steps of:

2 a) providing a stream containing gaseous chlorine and chlorine
3 dioxide

4 b) passing the mixed chlorine/chlorine dioxide stream through a
5 porous bed of sodium chlorite to produce a stream of substantially pure chlorine
6 dioxide;

7 c) injecting chlorine into said water being treated at a point in the
8 process after removal of sufficient organic material such that the level of
9 chlorinated organics created is at or below an acceptable level; and

10 d) using the chlorine dioxide stream to oxidize contaminants and
11 disinfect drinking water at a point in the process before sufficient organics have
12 been removed to allow treatment with a stream containing substantial amounts of
13 chlorine.

1 38. A process according to claim 37 including the step of
2 injecting ammonia into said water containing chlorine entering the distribution
3 system to convert said chlorine to monochloramine.